

# Hot Iron

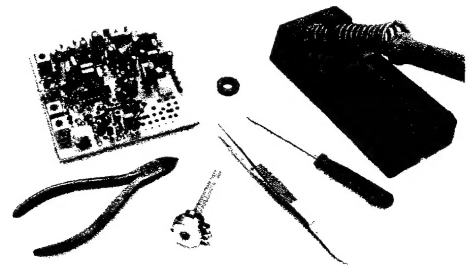
Autumn 2003  
Issue 41

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## Editorial

Firstly I must apologise for the delay in getting this issue of Hot Iron out to you. Many of you will know that I farm by day and August is a pretty busy time with harvesting etc. Apart from that, what has really taken my time, day and many nights, is the conversion of old Victorian barns into workshops for local businesses to rent. Back in mid-June we decided to have an open weekend at the end of August to give them a bit of publicity - but guess what - it took far longer to get them finished off than I anticipated - I still have to make the fire alarm work! (It is now!) My apologies.



The good news is that my good friend and regular contributor to Hot Iron, Eric G3GC, has now fully recovered from the illness that laid him low for a while in hospital with a longish spell recuperating at home afterwards. Unfortunately his wife then had a spot of trouble and also needed extra TLC but she too is now much better. Eric has decided to reduce his radio activities a little but I have a half promise that he will still do the odd article for us which is great; meanwhile any budding contributors, please speak up!

## Kit Developments

I reported last time that Eric had evaluated the prototype **Sidcot** CW 80m TCVR; following two more being kindly built by Andy Howgate and Don Winterburn, I decided that a few changes were desirable - mainly to increase the RF gain. These have now been done, and a pre-set RF gain control added so that it is now ready properly for Construction Club members. An article on the RX aspects is due to appear in the Oct issue of PW, followed by the TX aspects in the following issue. It is a specialist CW 80m only DC RX having a number of features not usually found in cheaper rigs, including a strong switching mixer, double tuned RF filters, narrow band-pass filtering for CW, proper RIT etc; with semi break-in TR operation, sidetone, low pass filters for the 1.5 Watt TX. It costs £44 plus £1 for post and packing.

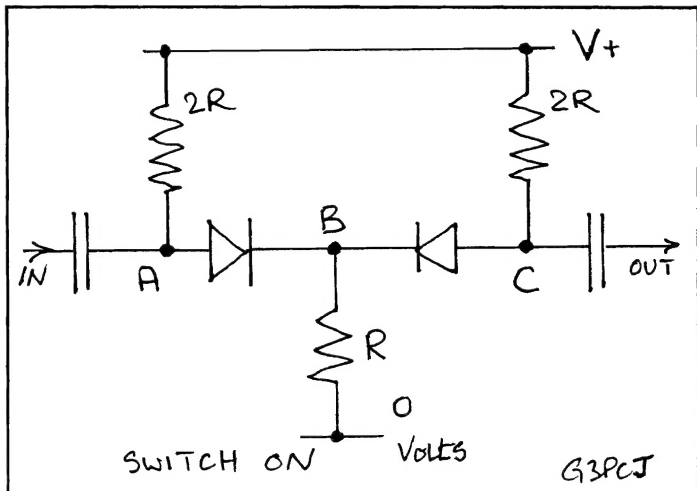
The next project will be a 'modern grid dip oscillator'; I have christened this the 'Dipsqueek' as I am trying to avoid using a meter or LED to indicate resonance, instead intending to use the change in pitch of an audio sound! I hope to make it pretty versatile with an RF output socket for feeding a counter or other test facilities. With a bit of luck it will thus double as a unsophisticated RF and AF signal generator! Tell me if you are interested. Tim Walford G3PCJ

**Hot Iron** is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

## Diode Switching

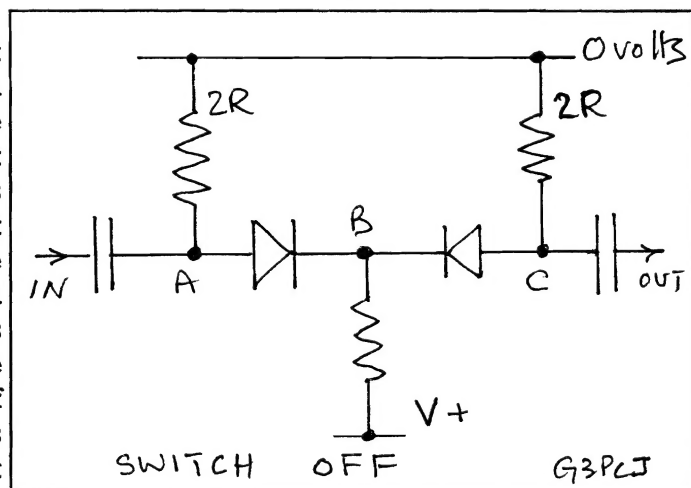
This is a technique which we probably ought to be using more often! Diodes can be used to 'switch' AC signals quite effectively in many low or even moderate power applications - the main advantages being high speed operation, usually lower power consumption than a relay, and probably lower cost; the main disadvantage can be worse isolation between input and output compared to most mechanical contacts, and unfamiliarity! They can be configured for simple on-off or multi-way switching. Examples of their use are for transmit/receive signal isolation between antenna and receiver while transmitting, and for changing the direction of signal flow through IF filters in superhet rigs. The frequency range can be almost from DC to light depending on the associated circuits which tend to have their impedances in parallel with the signal path. Isolating the RX input from the transmitter output voltages is pretty challenging so lets look at that first!

Consider the simple circuit right which is a diode 'on - off' switch, with the applied DC voltages arranged to forward bias both diodes. Under no AC signal conditions the point B will sit at half supply voltage if the diodes were perfect, because the current through the single lower resistance R will divide equally between the diodes and develop the same half supply voltage across each  $2R$  resistance. So if the AC input signal momentarily drags point A more positive, point B must follow and also go more positive. This will tend to reverse the voltage across D2 but since there is nothing to prevent the voltage on point C rising it will also go positive. If point A goes negative due to the signal input, then point B will also go negative as R draws point C negative; the negative signal limit will occur when all the current through R comes from the  $2R$  connected to point C because D1 has become reverse biased. The positive signal limit comes when point B exceeds the supply voltage, this will be somewhat larger than the negative limit. Hence the negative excursion determines the maximum amplitude signal that the switch can handle. In a practical circuit the values of R would be arranged to be a few times the source and load impedances; they could be actual resistances or RF chokes with extra resistors to determine the DC currents. The choke impedances should be well above the circuit impedance.



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Consider now the second diagram right where the DC supply voltages have been effectively reversed. We will see this has the effect of turning the 'switch' off so isolating input and output. Under DC conditions, both diodes are reversed biased and do not conduct so that points A and C are at 0 volts, and B is at the supply voltage. If now the AC signal takes A positive, D1 will not conduct until point A goes above the supply; however D2 will still be reverse biased so point C still does not alter. If the input takes A negative, then D1 becomes even more reverse biased and again the output is unchanged. Hence no signal gets through! In a practical circuit, the diodes will have some capacitance so there will be some leakage and the isolation will not be perfect but quite sufficient to protect the receiver's front end filters!



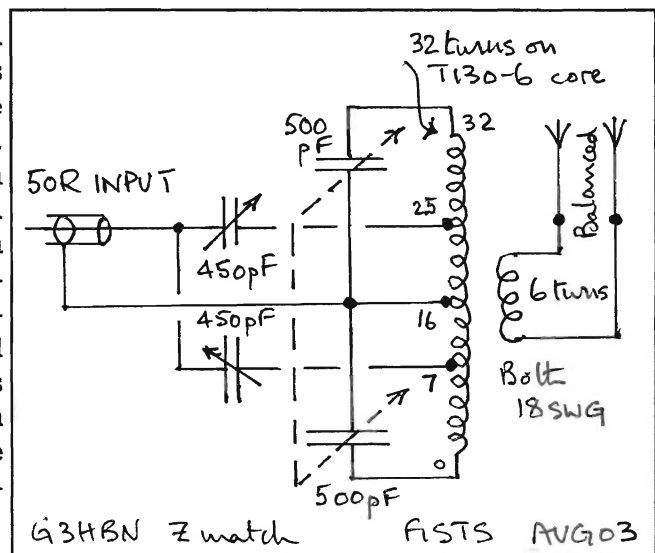
In a practical circuit, the diodes will have some capacitance so there will be some leakage and the isolation will not be perfect but quite sufficient to protect the receiver's front end filters!

Normally the rig's TR circuits will change the supply polarity to the diodes. With a little extra cunning in the control circuits, half of such a switch can be used to route the desired RF signals to the receiver's input RF bandpass filters; this involves connecting the other RF BPFs through further diodes to the mid point B of the TR switch. Only the diodes of the wanted BPF are turned on. I hope to use this approach in the TR and band selection aspects of the forthcoming **Locking 20, 40 & 80m CW transceiver. G3PCJ**

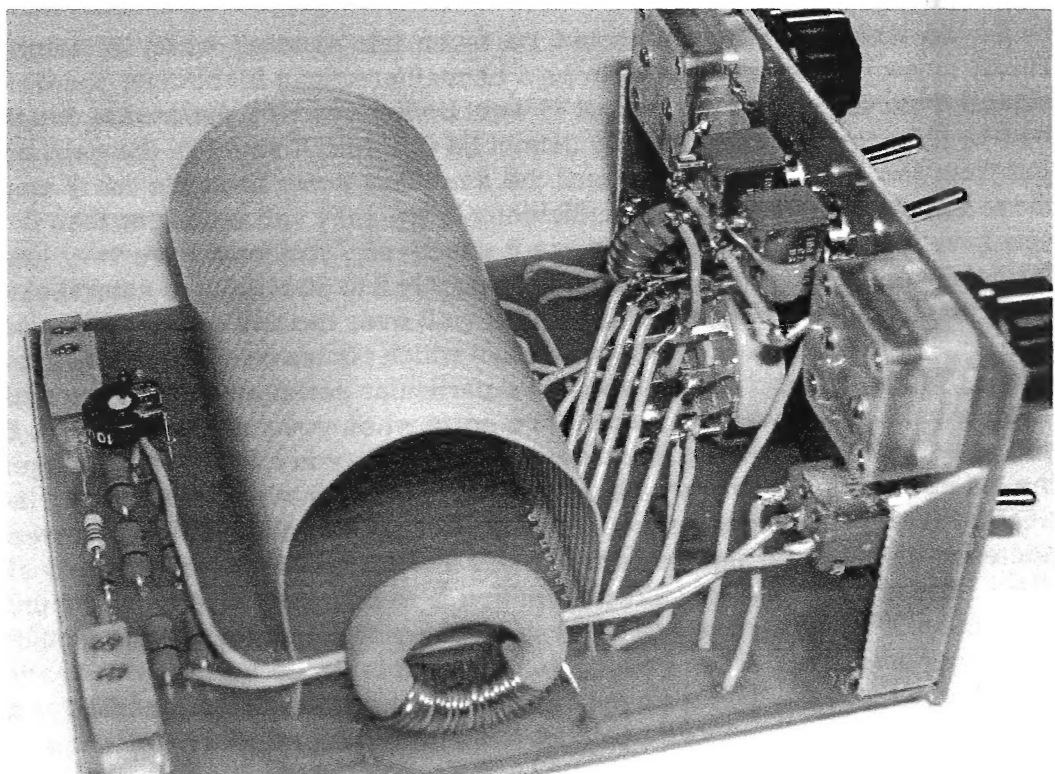
## Antenna topics!

**Monopoles!** There have been several developments following my note last time about the G5IJ! My thanks to Radcom columnist Steve Hartley G0FUW who took up the story! Firstly I got the dates of the PW article wrong, it should have been August 2002 so perhaps it was not intended as an April fool joke as I feared! Steve asked for reader's comments; he tells me that he has had several and will be reporting them in due course. He also looked up the earlier note from G5IJ printed by Pat Hawker G3VA in TT of Radcom March 1996. The TT note had explanations by the originator of its method of working but G3VA had also been a bit sceptical about this scheme; however, he did try it out and did find that it worked well on 7 Mhz. This is supported by our members Dave Buddery and Andy Howgate who have both used it. My own impression (and without any practical experience of it) is that it is acting probably as a quarter wave roughly on 7 MHz, loaded against whatever the rigs earthing scheme happens to be. I still don't understand how it can work sensibly over such a wide frequency range effectively. As many have observed, under favourable conditions, even a bit of wet string can give good results so I think this is a case of good luck primarily! I shall be delighted to be proved wrong! I think the toroidal transformer contributes practically nothing and the radiating element would work just as well if connected direct to the rig with an AMU and counterpoise.

**Balanced AMU** Dave G3OEP also kindly sent a note from the August 2003 FISTS, the CW operators Club Newsletter, outlining a different Z match style AMU from G3HBN. The brief details are shown right. It has three variable capacitors; a conventional main tuner (with split-stator) across the main inductor and two from the input to symmetrical taps on that main inductor. Unfortunately the whole article was not forwarded so I don't know the reason for this arrangement - I half expected two un-symmetrical feed taps - being used for low and high frequency bands etc.! Having a centre tapped main inductor with an output secondary wound over its middle this scheme does provide a true balanced output suitable for balanced feeders and radiating elements.



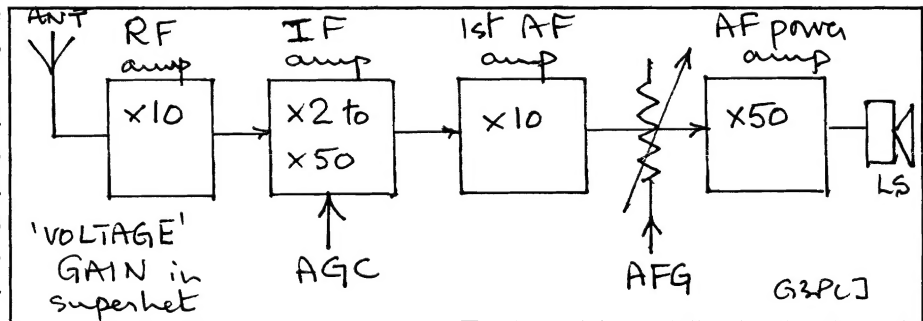
Here is another AMU but this time using the T match C-L-C approach. It incorporates a RF transformer at the input to the matching section so that the output is (almost) floating and can drive a balanced feed line and antenna. The kit also includes a resistive matching bridge and was reviewed in the July 2003 PW.



## **The Three S's - sensitivity, selectivity and stability!**

These three aspects of a receiver almost totally determine its performance! People write books on each one but I will spare you that and most of the maths! A page on each over future issues should be enough. Firstly let's consider *sensitivity* and the order of overall typical gain required in a receiver. Suppose it is to produce 20 mV into a loud speaker for an input signal at the antenna of 2  $\mu\text{V}$ . This would not be full LS output but is usually easily heard and might be sufficient for our weak input signal. This implies a voltage gain of 10,000. The same gain would (in principle) produce a useful audio output of 100 mV to the LS for a more typical input of 10  $\mu\text{V}$ . Bear in mind that S9 is often taken to represent 50  $\mu\text{V}$  signals. I know I am using these levels rather loosely but it is not uncommon for receivers to have a gain of more than 100,000 which allows for some losses or attenuation in mixers and filters. Of course, for really strong signals the gain is reduced, either manually with the AFG pot or by automatic means where AGC is applied to some of the amplifiers. In expensive receivers, the AGC control range will be large so that the signal level at the input to the AF gain pot will be held essentially constant over a very wide range of RF input signal levels.

Years ago, when high impedance phones were used, far less gain was needed because the phones had much higher sensitivity and they were placed right on your ears! This explains why it was possible to hear signals with a crystal set probably not having any gain - especially for the milli-volt RF signals from broadcast stations! (I once measured half a volt on my antenna lead from a 4 MHz BC station!) The above figures explain why the very simple 'single transistor does all' circuits are fun but never much good because they have only a tiny fraction of the gain needed for serious use. So how do you obtain a voltage gain of 10,000 or even 100,000? With great caution if it is all at audio frequency as in simple direct conversion receivers! It is highly likely to oscillate so the gain is nearly always spread over several different frequency bands - typically three in a superhet; at RF, IF and AF. Often there will be facilities to control the gain of each of these blocks either automatically or manually. These 'gain controllers' also help to divide each gain block physically so there is less likelihood of oscillation in each one. This leads to a 'gain' block diagram like that on the right - which is typical of a superhet. I have indicated some typical gain figures for each stage.



So what other factors should be taken into account when deciding the gain allocations? Firstly noise; this pesky aspect can be a bit mathematical! All circuits generate very small electrical signals even when there is no input - I won't bother you with the causes, but these noises get amplified by subsequent stages so they cannot be ignored. If you turn the gain right up, without any input from the antenna, you will hear the amplified noise from the early stages of the receiver. If these self-generated noises are sufficiently large, they will be larger than the wanted signals. So if you have lots of gain available, to use it effectively, you must have very low self-generated noise from the front end. For the HF spectrum (roughly 2 to 30 MHz), the natural electrical noise collected by a reasonably sized antenna should be well over the self-generated noise of the receiver front end. The antenna is receiving cosmic noise which comes from distant thunderstorms all around the globe. Hence the acid test of whether a particular aerial and receiver combination has sufficient sensitivity, is to see what happens to the noise when you plug in the aerial. If it does NOT change, you are only hearing the rig's self-generated noise - you either need a bigger aerial or to redesign the RX front end! If however, the noise level increases when you connect the aerial, then you are hearing the cosmic noise and all is well. (Strictly you should swap between a 50R resistor connected to the rig input and the aerial for this test but the difference is nearly always not detectable.)

The other aspect of gain distribution is to consider what happens under large input signal conditions. If there is a fixed gain of say 1,000 before the gain varying facilities, then a 1 mV signal would become 1 volt at the gain control stage; this would be near the overload limit of the output amplifier of these fixed gain stages (let alone subsequent stages!) leading to all sorts of trouble. It is essential to have only sufficient gain for the largest likely signal to just cause overloading of the output of the fixed gain stages. Next time I will write about the filtering circuits. G3PCJ

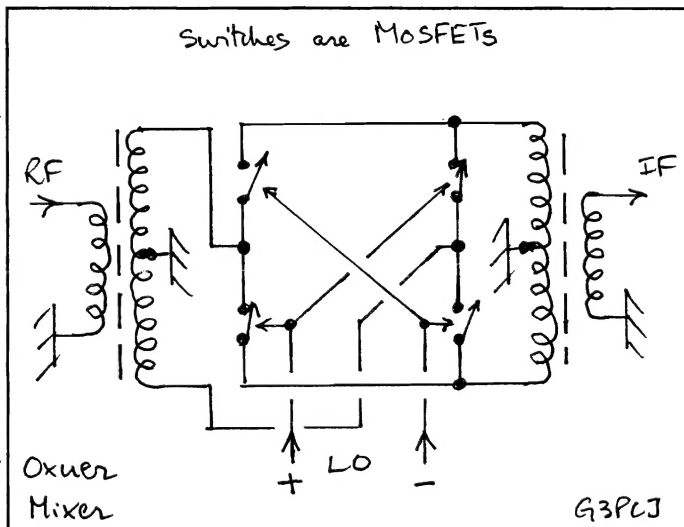


## Switching Mixers

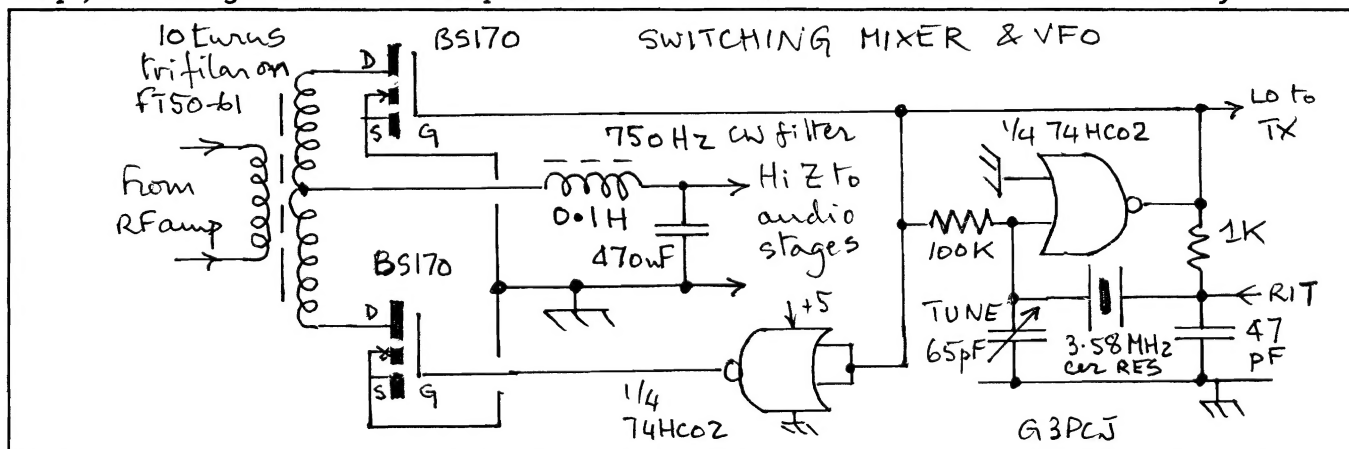
Over recent years there has been much emphasis by receiver designers on improving large signal handling ability. This is particularly important when very large unwanted signals are present close in frequency to very weak wanted ones - 40m is the classic example where the signals from broadcast stations above 7.01 MHz are huge compared to our wanted the weak DX! The classic symptom of an inadequate mixer frequently occurs in DC receivers, where the strong station comes through as mushy noises or BCI. Mathematically, signal handling ability is measured by the third order intercept point, often abbreviated to IP3. In recent designs, where there is limited gain at RF, it is the first mixer which often causes the problems. Hence the interest in what have become called strong mixers, or ones able to handle large signals.

The mixing process is a funny mix of both linear and non-linear processes! In the simple common situation, the wanted variable level RF signal is mixed with a large local oscillator (LO) signal to produce a variable level IF or AF output at either the sum or difference frequency. Without some non-linearity, caused indirectly by the large LO signal, no mixing can actually take place; and yet the IF output has also to be directly related in a linear manner to the RF input! It is this latter point where they fail as the input signals get larger. Often, the detail circuits are arranged to be balanced in order to minimise any undesired effects transferring from one 'port' to another. (The 'ports' are the three inputs/outputs.) The classic doubly balanced diode mixer is excellent but the maximum signal level is limited to roughly that which the diodes can handle from the high power LO input. Stronger versions of the common SBL-1 mixer can take up to +17 dBm but this is not really enough!

Recently, attention has turned to the use of FETs as the non-linear element instead of diodes. In a 'switching' mixer, the switch element - the FETs - are turned either fully on or off by the LO signals. Oxner's original suggestion is shown right & has been further developed into H mode mixers - but they are quite complex and beyond this note. (Radcom's TT has had several notes on mixers from about 2000 to 2003.) I offer a somewhat simpler scheme, with lower but adequate performance for most, using the cheap and plentiful BS170 MOSFET driven by digital signals. The turn on threshold of the BS170 is just over 2 volts so it lends it self very nicely to being driven by 5 volt digital logic.



I have incorporated a partially balanced version of this into the mixer in the SIDCOT CW receiver, which is shown below with the driving variable frequency local oscillator. The latter is actually a 'digital VFO' in that the output is a square wave running between 0 and 5 volts. (I appreciate the waveforms around the resonator are not digital, but this is not the digital VFO of commercial rig where a microprocessor input commands the output of a single wide range Direct Digital Synthesis chip!) This design has an audio output to the first CW filter but it could also be at IF. G3PCJ

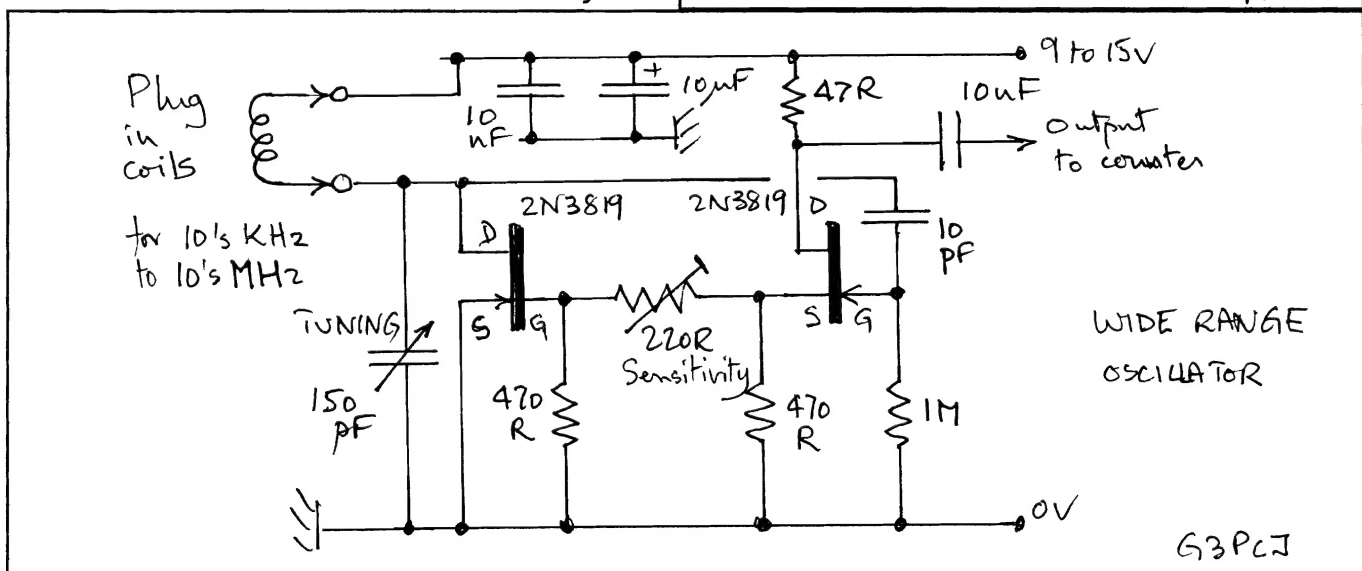
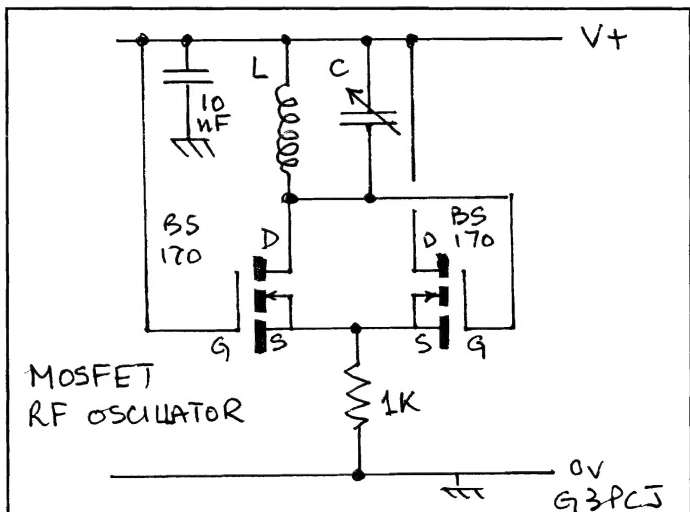


## Oscillators for dip meters

After some quite severe prodding by several Construction Club members and Rob Man-nion, G3XFD Editor of PW, I have begun a Grid Dip Oscillator (GDO) project. The basic principle being that, when an unknown resonant circuit is brought near an oscillating LC tank circuit tuned to the same frequency, the unknown LC sucks out some energy from the oscillator causing a change in bias conditions which can be indicated on a meter. Of course the GDO name derives from earlier days when valves were used and the approach was to show grid bias resistor current on a sensitive meter. I still frequently use my 40 year old Heathkit GDO but it does have the drawback of being quite big and needing a mains lead. (I have not had cause to look inside since I built it all those years ago and hate to think what quality of solder work that I might find inside!)

The first item to consider was the type of oscillator that should be used. As ever simplicity and certainty of working are pretty important but for a GDO there is another very important point that was recently mentioned in PW by our occasional contributor Gerald Stancey G3MCK. Although one must be certain that the oscillator will start properly, the amount of feedback in its internal loop should not be excessive; this ensures that when the extra loading occurs due to the coupled circuit, the change in conditions will be quite large leading to a sensitive instrument. In other words, it should be possible to quite easily stop the oscillator!

I tried out several different oscillator configurations such as the familiar Hartley circuit which can easily work over the wide range of frequencies needed for the instrument. But this does have the drawback of needing a tapped coil and three connections for the several plug-in inductors that would be required for a range of at least 2 to 30 MHz. Other common 2 lead inductor circuits like the Colpitts can have limited tuning ranges due to their internal fixed capacitors. I eventually choose the one that I have used before in the signal generator kit. This has always worked well and with a very wide range of frequencies right down to tens of KHz! However the normal circuit did seem a bit unyielding when coupled to the unknown so I thought about how to reduce its internal gain. For amusement, I show right a very low parts count MOSFET version that I explored. I eventually decided against this because the tuning range was limited by the input capacitance of the BS170s but it does work well! The JFET version does not suffer this problem and gain can easily be controlled by using separate source resistors and a low value preset to link them as shown below. A further refinement is to have a RF output for a counter or other purposes. If the frequency can be measured accurately, it makes life much easier and also permits component values to be measured based on the difference in frequency when an unknown is added to the tuned circuit. G3PCJ



## **Snippets**

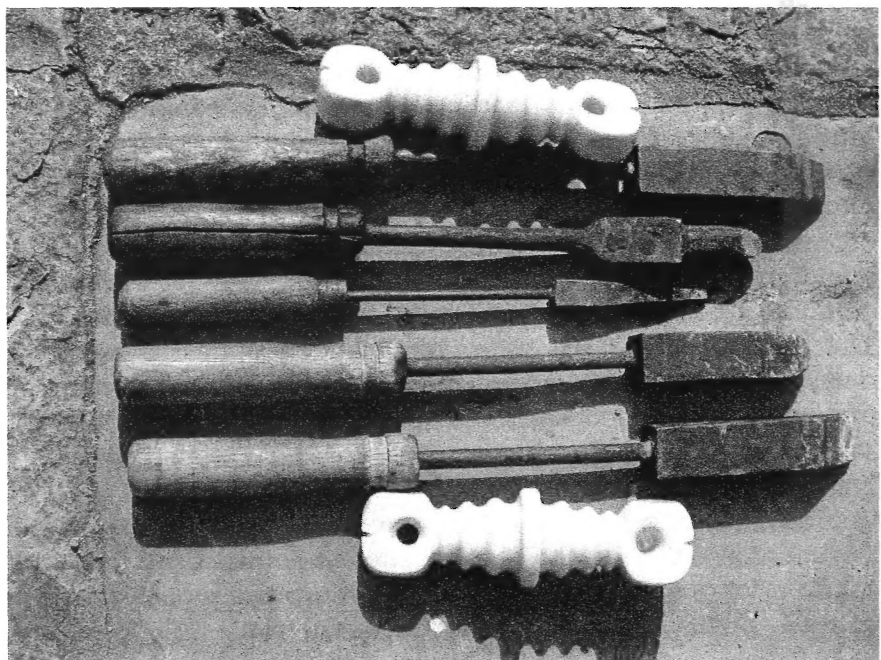
**'Mechanics'** Charles Wilson reminds us of two important points. Firstly that VFO coils should have their turns cemented in position with a material, such as Balsa glue or Bostik. Even though they may seem tight and immovable on whatever type of former is used, in all probability they will be able to vibrate or even shift with temperature changes if not cemented in place. Such vibration can cause microphony in DC rigs. The best coil formers are made of ceramic but these are now very rare. Powdered iron toroidal cores are the next best, and will have less turns (hence less potential for change) than air cored inductors. Avoid PVC type plastic materials (such as overflow pipes), wood or worse for VFOs! These materials can be used as formers with caution in the HF range for general tuned circuits where the exact resonant frequency is not extremely critical as is the case for a VFO.

Charles' second point concerns heatsinks, especially big ones. His professional experience has shown that the inertia of even quite small heatsinks is sufficient to rip heatsinks and their devices from a PCB when not properly supported mechanically. This happens when packing the car in haste for field trips! More accurately its called chucking things in the boot! His suggestion is that any heatsink should be attached by nuts and bolts to the rig's case; this may involve repositioning the device and heatsink but provided the leads are kept as short as possible, it is feasible for devices working at up to 'middleish' HF!

**RF chokes** Craig Douglas asks how to determine the value of choke that should be used when home-brewing a circuit. Generally the value should be high enough so that its reactance, at the frequencies in that part of the circuit, should be several times whatever other impedances are present at that point. This can be difficult to judge! For example, if an RF amplifier collector choke is driving a 50R load, then its reactance at the lowest frequency should be not less than around 200R. If its being used down to 2 MHz this leads to a choke value of about 22 or 47 micro-henries. If the load is lower, say 12.5R for a 5W RF amplifier one can get away with 10 micro-henries. Often the choke has also to carry considerable DC current as well so bear this in mind - the plastic encapsulated ones are not always adequate in such circumstances. In some situations such as TRF sets the choke may be blocking RF and AF signals so the value has to be very much bigger, or possibly an audio transformer instead! In the valve era, the RF choke in the final RF power amplifier was always a critical item especially if it had to work over a wide frequency range such as 2 to 30 MHz. The load on the valve had a high value (a few K) and the choke reactance had to be even higher; however if it was self resonant at some part of the range, there was a fair chance it would melt! Often it was its own inductance resonating with its self parallel capacitance - the cure was to divide it into sections each having different numbers of turns - in effect two or three different value chokes connected in series. This is rather like using 3 capacitors (10  $\mu$ F, 100 nF and 1 nF) in parallel for effective bypassing over a very wide frequency range. Another approach was untidy hand 'pile' winding!

### **A little amusement!**

Here is some of my most recently acquired soldering equipment. I am tempted to offer a small prize to whoever can correctly identify their previous immediate owner but that might be a bit too easy! Perhaps it should be who was their 'original' owner?! Any suggestions?  
G3PCJ



## Pulling crystals

David Proctor G0UTF reports improving the frequency range for his Dundon CW transmitter. He has crystals for three bands 7, 10 and 14 MHz together with 3 sets of low pass filters on the TX output. He has worked all around Europe with just over the 1 Watt which it produces on a 12 volt supply. Bearing in mind the Dundon is stand alone separate CW TX with TR changeover etc, he uses it with a separate superhet receiver. He only sent me part of the circuit so I have guessed the rest and repeat it right!

His alteration from the original is to add selectable inductance which now gives a very useful frequency range on all three bands when tuned with a proper 50 pF variable capacitor. David has arranged the choice of inductance with three tiny toggle switches. The 30  $\mu$ H coil is a TOKO 3333 with the core just out and the two 4.5  $\mu$ H ones are TOKO 3334s. They will pull further, but.....

<u>Band</u>	<u>L = 0</u>	<u>L = 4.5</u>	<u>L = 9</u>	<u>L = 30</u>
		<u><math>\mu</math>H</u>	<u><math>\mu</math>H</u>	<u><math>\mu</math>H</u>
<b>40m</b>	7.029 to 7.031		7.028 to 7.030	7.021 to 7.028
<b>30m</b>	10.105 to 10.107	10.103 to 10.106	10.100 to 10.104	
<b>20m</b>	14.059 to 14.061	14.051 to 14.51		

The Tribant-2 Last time I floated a scheme for a 20/40/80m antenna that should not need an AMU when properly adjusted. As described it needed a 50R twin feeder, some of which was the vertical radiating element on 80m, with the rest acting as a loading coil or choke balun on the higher bands. The search for a source of such feeder has been fruitless. There are plenty of styles of twin 'figure of 8' cables but they all seem likely to have impedances of around 100R or higher which would defeat the objective of avoiding an AMU. I later realised that the vertical section could also be 50R coax which makes it rather more practical! The revised details are shown right but I emphasize that it has yet to be tried out - so coil details are lacking to resonate any particular vertical section. For QRP uses, the smaller 50R coax should be quite adequate and could be wound into a lightweight coil easily.

It would be great if one of our members cared to experiment and tell me the results. The cynic might say that a random long wire and AMU with counterpoise would work as well - but it would not be such fun as the trials! G3PCJ

